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Conflicts between humans and wild animals in and surrounding protected area (Bahia, Brazil): an ethnozoological approach

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ABSTRACT

Conflicts between humans and wildlife have been considered a huge obstacle to the management and conservation of fauna, and also lead to negative impacts for local populations. For this reason, from an ethnozoological perspective, the present work aimed to identify and analyze conflicts between farmers and the wild fauna in four communities of the Costa de Itacaré-Serra Grande Environmental Protection Area, Bahia, Brazil, as well as diagnose the control measures used. The participants were selected using the snowball technique and data were collected using semi-structured interviews, complemented by free listing techniques, nonspecific prompting, and reading back. Thirty-eight farmers were interviewed and they reported 45 species of wild animals, among which 23 were mammals, 17 were birds and 5 were reptiles. Conflicts were classified into five categories. Of these categories, animal-cultivation and animal-livestock interactions had the highest number of reported species. The farmers applied different control measures, including defensive methods, which are the most frequently used in the communities, offensive methods, and superstitious rituals. Positive interactions were also identified, in which some species are considered charismatic or recognized for their ecological role. Conflicts with wild fauna are recurrent in these communities; thus, it is necessary to guarantee social participation in the construction of effective strategies for conflict mitigation and fauna conservation.

Keywords: Farmers; Protected Areas; Conservation; Ethnozoology.

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INTRODUCTION

The interaction human cultures have with fauna is one of the basic connections between humans and the environment (Marques 1995). In a local context, animals can acquire different meanings, ranging from utilitarian values, such as food and zootherapy, to the establishment of emotional, spiritual, and symbolic connections (Alves 2012; Hunn 2011; Roca and Corona 2017).

Attitudes and behaviors directed to fauna are molded by the range of values, knowledge, and perceptions, as well as the nature of the relationships between people and animals (Drews 2002). Moreover, interactions between humans and wildlife are not always evaluated as harmonic, and, on some occasions, may trigger conflicts in which animals are considered competitors or harmful to human populations (Alves 2012; Alves and Souto 2015). Human Wildlife Conflict (HWC) occurs when animal behaviors and needs negatively impact human interests, and vice versa, generating damage or losses to one or both sides (Distefano 2005; Madden 2004).

This problem is one of the main challenges to fauna management and conservation. Furthermore, it is an obstacle to conservation biology when the answer to conflicts is the lethal control of the species involved (Dickman 2010; Kaltenborn et al. 2006). In most cases, losses resulting from damage caused by animals can lead to intolerance of people to wildlife (Senthilkumar et al. 2016). Similarly, HWC directly and negatively affects human well-being, health, and safety, and entails social and economic costs (Distefano 2005; Madden 2008). Several anthropic factors may also increase conflicts, especially destruction and fragmentation of habitats, transformation of land use, changes in agricultural practices, population growth, and expansion of human settlements inside or near vegetation areas (Distefano 2005; Marchini and Crawshaw 2015).

Conflicts usually emerge when animals invade or destruct crops or properties, when they attack or represent a potential risk to livestock and humans or when they transmit diseases (Madden 2008; Mendonça et al. 2011). This contact between people and animals occurs in both country and urban areas, although it tends to be more frequent when there is spatial overlap of resource use between humans and wild fauna, which is common around protected areas (Distefano 2005; Pettigrew et al. 2012).

Farmers and populations in several parts of the world, such as Africa (Braga et al. 2016; Dunham et al. 2010), North America (Garcia-Alaniz et al. 2010; Poudyal et al. 2017), South America (Marchini and Crawshaw 2015; Mendonça et al. 2011), Asia (Senthilkumar et al. 2016; Pettigrew et al. 2012) and Europe (Babai et al. 2017), have been suffering negative impacts in the breeding and raising of domesticated animals due to conflicts with wildlife.

In Brazil, the frequency, intensity, diversity and geographic range of these conflicts increased in the last decade (Marchini and Crawshaw 2015). Marshall *et al.* (2007) point out the importance of interdisciplinary approaches, considering social factors, to comprehend HWC and develop sustainable solutions. This subject, however, has been poorly explored from an ethnobiological viewpoint (Schulz et al. 2014).

Thus, from an ethnozoological perspective, the present study aimed to identify and analyze conflicts between the local population and wild animals in the Environmental Protection Area Costa de Itacaré-Serra Grande, Bahia, Brazil, in order to characterize the types of conflicts between people and wildlife, identify species and control measures used and, consequently, contribute to fauna conservation and management efforts.

MATERIAL AND METHODS

Study area

The Environmental Protection Area (APA – *Área de Proteção Ambiental,* in

Portuguese) Costa de Itacaré-Serra Grande was established in 1993 by State Decree No. 2186 and expanded in 2003 by State Decree No. 8649, and it now totals 62,960.16 ha that cover the municipalities of Ilhéus, Itacaré, and Uruçuca (Brasil 2004).

According to Ecological-Economic Zoning, the territory of the APA is formed by twelve management zones (Brasil 2004). The present study was conducted in four communities distributed in the following four management zones: Camboinha, located in the Agricultural and Agroforest Conservation Zones; Tesouras, located in the Conduru Special Protection Area, which corresponds to Serra do Conduru State Park; Nova Vida rural settlement, located in the Agroforest Conservation Zone; and Serra Grande district, located in the Serra Grande Reference Plan of Development and Environment (Figure 1).

The APA is included in a region where the Atlantic Forest domain and its associated ecosystems are predominant and mostly consists of dense ombrophilous forest, mangroves, herbaceous, shrub-like and arboreal sandbanks, depression areas (wetlands and lagoons) and an area of relict vegetation locally known as *campo cheiroso* (Bahia 1996; 1998; Brasil 2004).

The region also includes other important conservation units besides the APA Costa de Itacaré-Serra Grande such as the Serra do Conduru State Park (PESC), created in 1997 with 9275 ha (Bahia 2005). Moreover, the highest diversity of arboreal species per hectare in the world was identified in this area and consists of 458 species in a single hectare (Bahia 2005; Martini et al. 2007; Thomas et al. 1998).

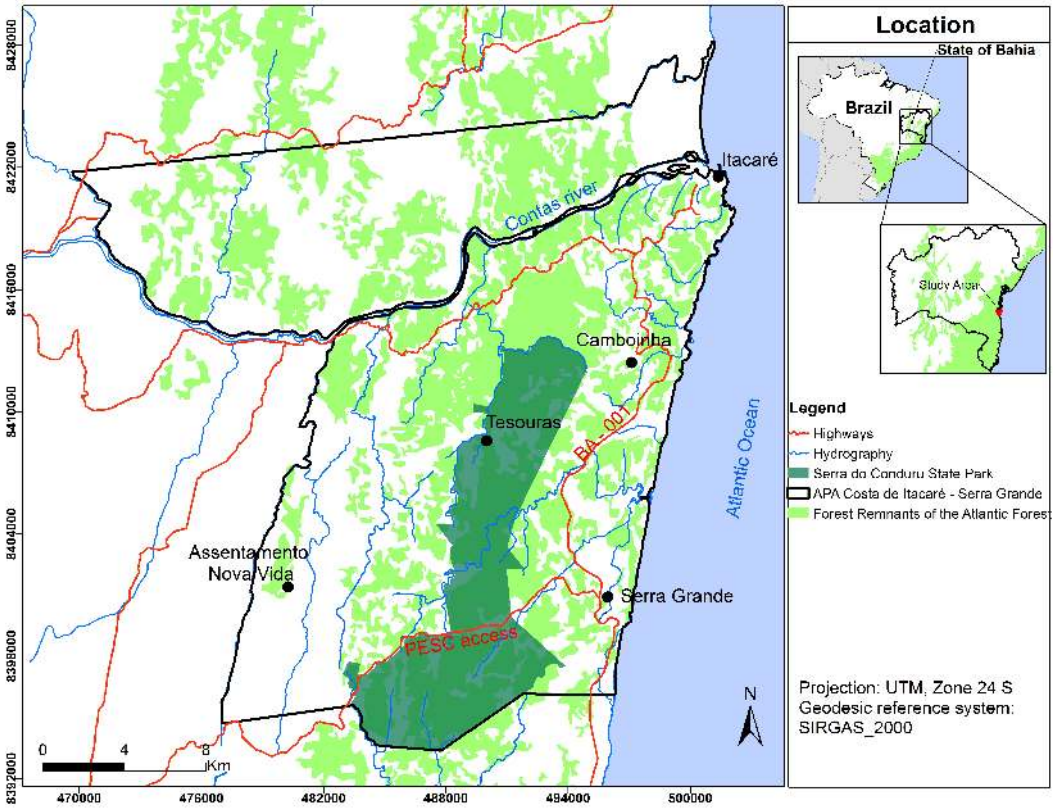

Figure 1. Map of the study area showing the distribution of the studied communities: Camboinha, Tesouras, Nova Vida settlement, and Serra Grande (APA Costa de Itacaré-Serra Grande and State Park Serra do Conduru, Bahia, Brazil).

Southern Bahia has the most significant portion of the Atlantic Forest in the northeast region of Brazil and a wide diversity of animal and plant species; it is also considered one of the most important centers of endemism in this domain (Araujo et al. 1998; Moura, 2003).

Cocoa (*Theobroma cacao*) is the main crop in the region and it is cultivated inside the agroforest system (SAF) known as cocoa-*cabruca* (Cassano et al. 2009; Sambuichi 2002). This system is essential for the conservation of forest remnants in the Atlantic Forest in southern Bahia since it also serves as an ecological corridor and habitat and provides resources for many endemic species (Cassano et al. 2009; Sambuichi 2002).

Data collection

Fieldwork was conducted from December 2016 to May 2017. The participants were selected using the snowball technique (Bailey 1994) according to the following criteria: farmers, over the age of 18, with records of wild animal conflicts in their properties.

Data were collected using semi-structured interviews (Albuquerque et al. 2010) that lasted 20 to 50 minutes. Statements were recorded with a recorder with the prior consent of the participant and subsequently transcribed in full. The interviews were conducted with only one resident of each household to prevent overlap in a sampling unit.

The field script was divided into three parts: I) sociodemographic factors; II) damage caused by wild animals to agricultural crops and control measures used; and III) predation of domesticated animals and control measures used.

During the interviews, we also used the free listing technique (Borgatti 1998) that consists of stating one issue of interest in a domain and asking the participants to list elements for this domain. We complemented the technique with nonspecific prompting and reading back (Weller and Romney 1988).

Before each interview, the objectives and methodological procedures were explained to the participants and their formal written consent was obtained. This research was approved by the Ethics Committee of the State University of Santa Cruz (Protocol CAAE 61683516.2.0000.5526).

In order to identify the mentioned species, we conducted a previous survey of fauna species recurrent in the study area and built a catalog with the pictures of these animals (Bahia 1996; Brasil 2005; Lobão and Nogueira-Filho 2011; Ribeiro and Schiavetti 2009). During the interviews, the participants were shown the catalog to help them recognize the referred species.

Qualitative analysis

Interviews were qualitatively analyzed using the model of union of all individual competencies (Marques 1991), in which all the information related to the research theme is considered.

Species identification was based on popular names and knowledge about the occurrence of the reported animals and supported by taxonomists who are familiar with the species of this region, specialized literature and previous zoological (Argôlo 2004; Brasil 1996; Brasil 2005) and ethnozoological research (Lobão and Nogueira-Filho 2011; Ribeiro and Schiavetti 2009) conducted in the study area (Alves et al. 2012).

Studies related to conflicts between humans and wildlife were classified

according to the adapted classification of Peterson et al. (2010), who created nine categories of conflict based on a review of other works on the subject.

The control measures used by the interviewees to minimize or avoid damage caused by wild fauna were grouped according to the classification of Mateus (2013), as follows: 1) offensive methods, when the animal is slaughtered or harmed and 2) defensive methods when management strategies that do not kill or harm the animal are used. In addition, a third classification was created, called superstition rituals, which refers to rituals performed to ward off bad luck and damage.

Quantitative analysis

To determine whether the number of interviews was sufficient for data collection, a curve of species accumulation was created with PAST (Palaeontological Statistics), software version 3.18, with reliability interval of 95%, using the Mao Tau method (Colwell et al. 2004). The curve was built considering the number of wild species mentioned in all the communities and the number of interviewees.

With the generalized linear model (GLM; Crawley 2013), we evaluated the effect of sociodemographic variables, namely age, education, time living in the region (explanatory variables) for the number of cited species. In order to obtain adequate minimum models, non-significant explanatory variables ($p > 0.05$) were excluded.

Additionally, an analysis of residue was conducted to verify the adequacy of possible probability distribution and the error distribution of all models. When significant differences were observed among communities, the data were submitted to contrast analysis for aggregation of non-significant levels (Crawley 2013).

To evaluate if there was a difference in the composition of reported species in each community, the permutational multivariate analysis of variance (PERMANOVA, Anderson 2001) was conducted, where the influence of communities on the composition of species mentioned by the interviewees was tested using Jaccard distance and 1.000 permutations (Vegan Package; Oksanem et al. 2013). Data used in PERMANOVA analysis were represented by non-metric multidimensional scaling (NMDS).

Analysis of GLM and PERMANOVA were performed in Statistical R (R CORE TEAM, 2017) software version 3.1.0.

RESULTS

Sociodemographic profile of participants

Thirty-eight interviews were conducted with 31 men and 7 women aged from 24 to 78. Of these participants, 10 reside in Camboinha, 6 in Tesouras, 17 in the rural settlement Nova Vida and 5 in Serra Grande.

Most of the residents had finished the initial years (34.2%) and last years (31.6%) of elementary school or had not attended school (29%). All of them are farmers, except one merchant, who raised domesticated animals. The majority of participants (63%) had been living in the study area from 20 to 49 years.

Furthermore, most participants (78.9%) were subsistence farmers and also raised domesticated animals. The main crops they cultivated were cocoa (86.8%), followed by cassava (84.2%), corn (68.4%), banana (65.8%), pigeon pea (26.3%) and others with

Table 1. List of the species cited by interviewees, classified in 5 categories of conflicts, with percentage included

Class/Order	Family	Species	Vernacular name	Crops/ affected animal	N^0 citations (%)
ANIMAL- CROP INTERACTION					
MAMMALIA					
Artiodactyla	Cervidae	*Mazama gouazoubira* (Fischer, 1814)	*Corço*	Cocoa, *jenipapo*	5.3
	Tayassuidae	*Pecari tajacu* (Linnaeus, 1758)	Collared peccary, *caititu*	Cassava, yam, banana, corn, sugar cane	73.7
Carnivora	Canidae	*Cerdocyon thous* (Linnaeus,1766)	Crab-eating fox, *raposa*	Pineapple	2.6
	Procyonidae	*Procyon cancrivorus* (G. [Baron] Cuvier, 1798))	Crab-eating raccoon, *mão-pelada, meia-noite*	Sugar cane, banana	2.6
Didelphimorphia	Didelphidae	*Marmosa murina* (Linnaeus, 1758)	*Rato-cachorro*	Cocoa	23.7
	Didelphidae	*Metachirus nudicaudatus* (É. Geoffroy, 1803)	*Cuíca-de-quatro-olhos, jupati*	Cocoa	5.3
Rodentia	Cricetidae	*Rhypidomys mastacalis* (Lund, 1840)	*Rato-do-cacau, rato-paca*	Cocoa	55.3
	Cuniculidae	*Cuniculus paca* (Linnaeus, 1766)	Spotted paca, *paca*	Cassava, pumpkin	10.5
	Hydrochoeridae	*Hydrochoerus hydrochaeris* (Linnaeus, 1766)	Capybara, *capivara*	Corn, okra	5.3
Primates	Callithrichidae	*Callithrix Kuhlli* Coimbra-Filho, 1985	Wied's black tufted-ear marmoset, *sagui, mico*	Banana, *ingá*	10.5
Xenarthra	Dasypodidae	*Euphractus sexcinctus* (Linnaeus, 1758)	Yellow armadillo, *tatu-peba*	Cassava, sweet potato	63.2
	Dasypodidae	*Dasypus novencinctus* Linnaeus, 1758	Nine-banded armadillo, *tatu-verdadeiro*	Cassava, *dendê*	7.9

	Dasypodidae	*Cabassous tatouay* (Desmarest, 1804)	Greater Naked tailed Armadillo, *tatu-rabo-de-couro, tatu-do-rabo-mole*	Cassava	13.2
BIRDS					
Galliformes	Cracidae	*Ortalis araucuan* (Spix, 1825)	East brazilian chachalaca, *Aracuã*	Banana, guava	7.9
Passeriformes	Fringillidae	*Euphonia chlorotica* (Linnaeus, 1766)	Purple-throated eufonia, *gurin, guriatã*	Banana, guava, papaya	10.5
	Icteridae	*Gnorimopsar chopi* (Vieillot, 1819)	Chopi black-bird, *pássaro-preto*	Corn	39.5
	Icteridae	*Icterus jamacaii* (Gmelin, 1788)	Campo troupial, *sofrê*	Banana, guava	7.9
	Thraupidae	*Ramphocelus bresilius* (Linnaeus, 1766)	Brazilian tanager, *sangue-de-boi*	Banana, guava	5.3
	Thraupidae	*Tangara sayaca* (Linnaeus, 1766)	Sayaca tanager, *assanhaço*	Banana, guava, papaya	13.2
	Turdidae	*Turdus sp.*	Thrush (bird), *sabiá*	Banana, guava, papaya, chili	10.5
Piciformes	Ramphastidae	Unidentified species	Toucan, *tucano*	*Açaí,* banana	5.3
Psittaciformes	Psittacidae	*Aratinga auricapillus* (Kuhl, 1820)	Golden-capped parakeet, *jandaia, jandaia-testa-vermelha*	Corn, pigeon pea	47.4
	Psittacidae	*Brotogeris tiririca* (Gmelin, 1788)	Plain parakeet, *periquito-verdadeiro, verdinho*	Cocoa, corn	31.6
	Psittacidae	*Eupsittula aurea* (Gmelin, 1788)	Peach-fronted parakeet, *periquito-cara-suja, periquito-testa,*	Corn, pigeon pea	44.7

	Psittacidae	*Forpus xanthopterygius* (Spix, 1824)	Blue-winged parrotlet, *cuiubinha, tuim*	Corn	10.5
Tinamiformes	Tinamidae	*Rhynchotus rufescens* (Temminck, 1815)	Red-winged Tinamou, *perdiz*	Cassava	5.3
ANIMAL-LIVESTOCK INTERACTION					
MAMMALIA					
Carnívora	Canidae	*Cerdocyon thous* (Linnaeus,1766)	Crab-eating fox, *raposa*	Chicken, duck, turkey, helmeted guineafowl,	47. 4
	Felidae	*Leopardus sp.*	*Gato-do-mato, mamoninha*	Chicken	7.9
	Mustelidae	*Eira bárbara* (Linnaeus,1758)	Tayra, *irara, papa-mel*	Chicken	15.8
	Procyonidae	*Nasua nasua* (Linnaeus, 1766)	South american coati, *quati*	Dog, chicken	5.3
Chiroptera	Phyllostomidae	Unidentified species	Bat, *morcego*	Donkey, chicken, horse	5.3
Didelphimorphia	Didelphidae	*Didelphis aurita* (Wied-Neuwied, 1826)	Black-eared opossum, *sariguê, saruê*	Chicken, chicken's egg	21.0
Rodentia	Erethizontidae	*Sphiggurus insidiosus* (Olfers, 1818)	*Luís-cacheiro-amarelo*	Dog	13.2
Pilosa	Myrmecophagidae	*Tamandua tetradactyla* (Linnaeus, 1758)	Southern tamanduá, *tamanduá-mirim*	Dog	2.6
AVES					
Accipitriformes	Accipitridae	*Rupornis magnirostris,* (Gmelin, 1788)	Roadside Hawk, *gavião-pinhé, gavião-carijó*	Chicken	13.2
Falconiformes	Falconidae	*Caracara plancus* (Miller, 1777)	Southern crested caracara, *carcará*	Chicken	18.4
Falconiformes	Unidentified Family	Unidentified species	Sparrow-hawk, *gavião-pedrês, gavião-preto*	Chicken	21.0

REPTILIA					
Squamata	Boidae	*Boa constrictor* Linnaeus, 1758	Boa, *jiboia*	Chicken, chicken's egg, dog, cat	39.5
	Colubridae	*Drymarchon corais* (Boie, 1827)	*Papa-pinto*	Chicken, chicken's egg	15.8
	Teiidae	*Tupinambis merianae* (Duméril & Bibron, 1839)	Tegu, *teiú*	Chicken, chicken's egg	10.5
	Viperidae	*Lachesis muta* (Linnaeus, 1766)	*Pico-de-jaca*	Dog, cat	15.8
ANIMAL-FISHERY INTERACTION					
MAMMALIA					
Carnívora	Mustelidae	*Lontra longicaudis* (Olfers, 1818)	Neotropical otter, *lontra*	Fish, freshwater shrimp (*pitú*), duck	7.9
AVES					
Pelecaniformes	Ardeidae	Unidentified species	*Socó-branco*	Fish	2.6
ANIMAL-HUMAN SAFETY INTERACTION					
REPTILIA					
Squamata	Viperidae	*Bothrops sp.*	*Jaracuçu-boca-podre*	Human	7.9
ANIMAL-PROPERTY INTERACTION					
MAMMALIA					
Chiroptera	Unidentified Family	Unidentified species	Bat, *morcego*	Property	2.6
Rodentia	Unidentified family	Unidentified species	House mouse, *rato-de-casa*	Property	5.3

a similar percentage to that of cocoa and include fruits, vegetables, greenery and tubercles (86.8%). In relation to animals, most farmers raised domesticated chickens for food and sale (63.2%) and dogs were the most commonly mentioned pet (60.5%).

Human-Wild Animal conflicts

Forty-five species of wild animals were reported as being in conflict with the participants. Of these animals, mammals were the most representative (51.1%), followed by birds (37.8%) and reptiles (11.1%) (Table 2).

The curve of accumulation (n=45) tended to stabilize; however, an asymptote was not achieved, as shown in Figure 2, revealing that more species not recorded in this work can be in conflict with the participants. The communities of Serra Grande and the Nova Vida rural settlement reported 31 species and the participants of Camboinha and Tesouras reported 29 and 22 species, respectively. Comparing the number of species mentioned, a significant difference was observed among the communities (df=3, Deviance=12.8921, p=0.004), where Tesouras showed a higher number of species mentioned per participant (df=1, Deviance=15.451, p=0.007) (Figure 3).

The following analyzed sociodemographic

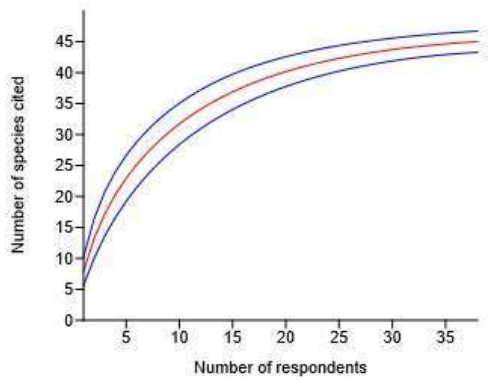

Figure 2. Curve of species accumulation, correlating the number of species mentioned and interviewees. Blue lines represent confidence interval (95%).

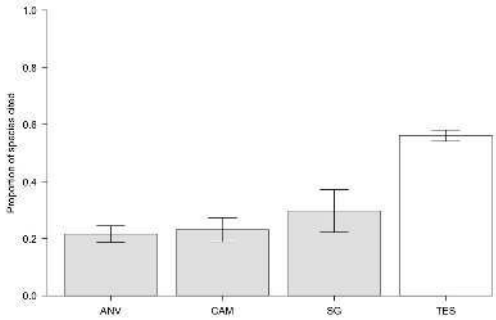

Figure 3. Analysis of contrast of the number of species mentioned in each community (ANV= Nova Vida Settlement; CAM=Camboinha; SG=Serra Grande; TES=Tesouras). Change of color in bars represents the significant difference.

variables did not affect the number of species mentioned in each community: age (df=1, Deviance=1.3765, p=0.24); education (df=4, Deviance=5.2939, p=0.26); and time in the region (df=1, Deviance=0.1358, p=0.71). Species composition among the communities showed dissimilarity (df=3, R2=0.2, p=0.0002, Figure 4) and only ten species were reported in all communities, some of which received the majority of complaints (Table 1).

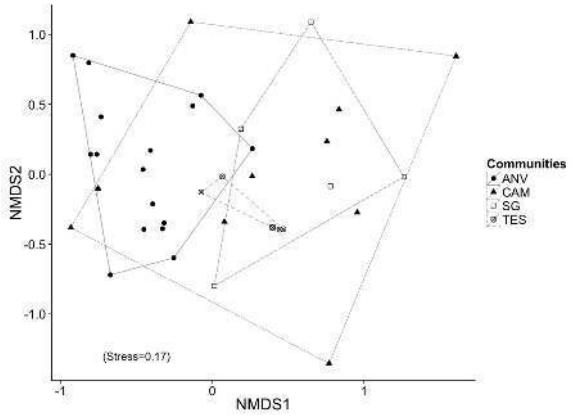

Figure 4. Diagram of the analysis of composition of the species mentioned in all communities (ANV= Nova Vida Settlement; CAM=Camboinha; SG=Serra Grande; TES=Tesouras; NMDS=Non-Metric Multidimensional Scaling).

From the qualitative analysis, it was possible to identify five categories of conflict. These categories were adapted according to the classification of Peterson et al. (2010), as follows: animal-crop interaction, animal-livestock interaction, animal-fisheries interaction, animal-human safety interaction, and animal-property interaction.

Animal-Crop interaction

This category includes conflicts due to invasion, consumption, or destruction of crops by wild animals. It was identified in all communities and comprised the highest number of species mentioned (n=26/57.8%), represented by birds and mammals, with 13 species each, affecting 18 agricultural varieties (Table 1).

Collared peccary (*Pecari tajacu*) was the most frequently reported species (73.7%), due to damage caused in the cassava crops (Table 1), followed by the yellow armadillo (*Euphractus sexcinctus*) with 63.2%, which damaged the cassava and sweet potato crops. The *rato-do-cacau* (*Rhypidomys mastacalis*) appears third (53.3%) and

damaged the cocoa crops (Table 1).

For birds, species of the Psittacidae family obtained the highest number of complaints, mainly for affecting the corn crops. The golden-capped parakeet (*Aratinga auricapillus*) was mentioned by 47.4% of the interviewees and the peach-fronted parakeet (*Eupsittula aurea*) was mentioned by 44.7% (Table 1). Chopi black-bird (*Gnorimopsar chopi*) also obtained a considerable number of mentions (39.5%) for damaging corn crops during cultivation and seed germination.

According to the interviewees, the species did not invade the crops at any specific time of the year. These events occur when there is availability of crops, during ripening and harvesting or when resources such as fruits and other food are less available in the forest, thus leading animals to attack plantations in search of alternative forms of food.

Animal-Livestock interaction

This category is characterized by attacks of wild animals to domesticated animals, generating conflicts. It was reported in all communities and obtained the second highest number of species mentioned (n=15/33.3%). Of these wild animals, eight are mammals, three are birds, and four are reptiles affecting eight groups of domesticated animals (Table 1).

For mammals, the order Carnivora was involved in the highest number of conflicts, especially the fox (*Cerdocyon thous*) (47.4%) (Table 1). Moreover, this species was the only one included in two categories for causing damage to pineapple crops and for attacking domesticated animals. In addition, it was reported as a risk of disease transmission to dogs.

Three birds of prey were listed as attacking chickens; however, only two were identified at species level: roadside hawk (*Rupornis magnirostri*) and southern crested caracara (Caracara plancus), with 13.2% and 18.4%, respectively (Table 1).

Among the reptiles, the boa (Boa constrictor) received the second highest percentage of mentions (39.5%). According to the interviewees, despite being considered a pacific animal, it mainly attacks chickens and pet animals (Table 1).

Animal-Fishery interaction

In this category, conflicts resulting from wild animals attacking fish or freshwater shrimp (*pitú*) used in commerce, subsistence or recreation were included. It was reported by the interviewees of Serra-Grande, Camboinha, and the Nova Vida settlement.

Two animals were mentioned in this category (4.4%): the socó-branco, which is a bird of the Ardeidae family, and the Neotropical otter (*Lontra longicaudis*), which was the most important species mentioned in this type of conflict, with 7.9% of reports.

Animal-Human safety interaction

This category is characterized by conflicts in which wild animals represent a death threat or risk for humans. This type of conflict was mentioned for Tesouras and Serra Grande. Only one serpent was included (2.2%), *jaracuçu-boca-podre* (*Bothrops* sp.), characterized as a dangerous species due to its poison.

Animal-Property interaction

Conflicts as a result of invasion or property occupation by wild animals were included in this category. It was reported in Serra Grande and the Nova Vida settlement.

Two animals were mentioned (4.4%): the bat (2.3%) and house mouse (5.26%); however, it was not possible to identify these animals at species level.

Control measures

The majority of participants (n=29/76.3%) confirmed the use of one or a combination of measures to prevent or reduce damage caused by wild fauna. Offensive methods are applied by 51.7% of the interviewees who stated they used control measures. These methods include direct slaughtering of the animal or use of poison, dogs, traps, shotgun, or slingshot against 15 species.

The species that appeared as a target of harmful attitudes were the collared peccary, fox and yellow armadillo, which were considered as low concerning (LC) in the list of the International Union for Conservation of Nature (IUCN) and did not appear in the Official List of Fauna Species Threatened by Extinction of the State of Bahia (Bahia 2017; IUC 2017.2). Additionally, the collared peccary, spotted paca, black-eared opossum, tegu, yellow armadillo, and parakeet are used as food after being slaughtered

Defensive methods are the most common measures and they were applied by 82.8% of the interviewees for 20 species. These methods include use of scarecrows, brightly colored fabrics and plastics, installation of cans on the plantations to make noise and fires (bombs) to scare the species of parakeet, chopi black-bird and collared peccary; the construction of chicken houses with screens to prevent the fox, black-eared opossum, tayra, birds of prey and boa from attacking chickens; cleaning and constantly attending to the field and spreading of cattle urine as a natural repellent in the plantations as a method of prevention against the collared peccary; pre-harvest production prior to full ripening to prevent bird attacks; and the installation of plant branches (‘*cansanção*’ and pepper) in the places bats usually perch.

Superstition rituals are used against the collared peccary, black-bird, and the Neotropical otter by 13.8% of interviewees who adopted control measures.

Positive interactions were recurrent and identified by 52.6% of interviewees, who stated they did not use control measures for certain species and conflict situations.

In these cases, participants demonstrated empathy and respect for animals. The decision to not use control measure was based on their belief that some species, such as the *rato-do-cacau*, need to find food. Similarly, they also felt admiration associated with the desire for proximity, mainly for bird species.

Furthermore, control measures are not used for some species when their ecological role is recognized, as in the case of the papa-pinto snake (*Drymarchon corais)*. Although this species attacks chickens, it is not usually killed by the interviewees because it is not poisonous and feeds on other venomous species.

DISCUSSION

Human-Wild animal conflicts

Overall, conflicts in terrestrial environments often occur involving mammals, especially carnivores and large herbivores; reptiles, commonly crocodilians and serpents; and birds, especially granivores and birds of prey (Torres et al. 2018).

The curve of species accumulation tended to stabilize, demonstrating that the sampling effort was sufficient. However, new

conflicts could be found, but the number of indications during participant selection (snowball) ended.

The higher number of species mentioned per participant in Tesouras can be related to environmental characteristics. All communities are near forest fragments, although Tesouras is located in a conservation unit called the Serra do Conduru State Park. The area is surrounded by vegetation that allows greater interaction between the population and wild animals. According to Distefano (2005) conflicts in these regions are usually due to a higher number of wild animals easily moving to nearby inhabited areas.

From our results, it was not possible to identify influences of sociodemographic factors on the number of mentioned species. In contrast, other works addressing the relationship between humans and fauna point out that factors such as education, gender, age, and country or urban environment affect the attitudes and perceptions of people regarding animals (Pinheiro et al. 2016; Serpell 2004).

Thus, different types of agricultural and cultivation practices, animal raising, and form of management, as well as environmental characteristics defining species richness could have influenced the number and composition of reported species rather than the sociodemographic factors.

Animal-Crop interaction

This form of interaction, which occurs widely around the world, is where mammal species are chiefly responsible for damaging crops. Examples include elephant invasions in plantations in Asia (Nath et al. 2015), crop damage caused by European boar (Sus scrofa) in Brazil (Pedrosa et al. 2015) and the United States (Poudyal et al. 2017) and damage caused by primates in Africa (Tweheyo et al. 2005).

The collared peccary was mentioned as mainly responsible for damaging crops in the studied communities. Moreover, it is considered an agricultural plague in some locations (Alves et al. 2016; Santos et al. 2009). Conflicts with this species and the yellow armadillo have been reported in previous works, in which they damaged cassava, banana, pupunha palm, bean and corn crops (Lobão and Nogueira-Filho 2011; Ribeiro and Schiavetti 2009).

The third most frequently mentioned species was the *rato-do-cacau*. Cocoa crops occupy a large part of the agricultural land in the region and significantly influence the economic sector. For this reason, problems with damage caused by rodents in these plantations are recurrent and identified in other works (Cruz 1983; Encarnação, 2001; Lobão and Nogueira-Filho 2011). As also reported by participants, Cruz (1983) reinforces that these vertebrates attack cocoa fruits in several stages of development by perforating the husk to feed on the mucilage covering the almonds and subsequently abandoning the seeds on the ground.

In relation to birds, conflicts with species of the Psittacidae family and the chopi black-bird have been reported in different regions of Brazil, where they damage crops of corn and other grains (Jacinto et al. 2007; Mateus 2013; Santos-Neto and Gomes 2007).

Many factors intensify this type of conflict, such as loss and fragmentation of habitats and changes in agricultural practices, thus increasing competition for resources and space between humans and fauna (Distefano 2005; Marchini and Crawshaw 2015). However, according to the interviewees and the observations of Tweheyo *et al.* (2005), the availability and

abundance of food near foraging areas and scarcity of food in forest areas depending on the season may influence crop invasions since the communities are near vegetation areas.

Animal-Livestock interaction

Attacks of wild animals on domesticated animals was the second most important type of conflict reported by the participants, especially fox attacks. Considered an opportunistic species, the fox is reported as a threat to livestock in many studies (Alves et al. 2016; Alves et al. 2012; Lobão and Nogueira-Filho 2011) and it is also known for invading crops and as a possible transmitter of diseases such as rabies (Mendonça et al. 2011).

Livestock predation by carnivorous animals is a recurrent and thoroughly investigated worldwide problem, especially in the case of big cats predating domesticated flock (Garcia-Alaniz et al. 2010; Palmeiras and Barrella 2007; Pettigrew et al. 2012; Schulz et al. 2014). In the study area, only *gato-do-mato* was reported, possibly related to the type of domesticated animals found in the area since this type of attack has been recorded for cattle, goats, and sheep, which were not reported as livestock in the studied communities, and may be related to the lack of or low frequency of big cats in the region.

Boa was the second most reported species in this category. Serpents are often considered harmful to people; however, three species were mentioned in the present study exclusively associated with domesticated animals. Similarly, boa was also described by Alves et al. (2012) and Mendonça et al. (2011) as representing a life threat to people and livestock. Moreover, Miranda and collaborators (2016) reported anaconda species (*Eunectes* sp.) as predators of domesticated animals, such as dogs, cats, and birds, in South America.

For birds of prey, conflicts with falcons and hawks were documented in previous works conducted in northeastern Brazil, in which they appear as a threat, mainly for cattle, goats, sheep, chickens, and ducks, leading to slaughtering as a control measure (Mendonça et al. 2011; Fernandes-Ferreira et al. 2012).

The presence of livestock in areas near vegetation can influence the occurrence of predation. In addition, poaching and habitat fragmentation may increase this type of conflict due to the reduction of the availability of natural prey (Azevedo and Conforti 2002; Borges et al. 2017; Schulz et al. 2014).

According to Marchini et al. (2011), illegal hunting of the natural prey of carnivorous animals contributes to the decline of food, which, together with the availability of domesticated animals near habitat remnants, leads to attacks of predators and an increase in conflicts. Hunting still occurs in this region for control, food and medicinal purposes (Castilho et al. 2017; Ribeiro and Schiavetti 2009; Teixeira 2018).

Other anthropic factors that may reduce natural prey are the inadequate use of fire, pesticides, parasitism, and predation by domestic dogs (Pitman et al. 2002). Additionally, inappropriate management of livestock can facilitate carnivorous attacks when these animals become more vulnerable to predation (Pitman et al. 2002).

Animal-Fishery interaction

Competition between humans and wild animals for fishery resources and damages caused to this activity have been registered in all regions of Brazil (Abade et al. 2007; Barbieri et al. 2012; Pinheiro 2016). Species

such as the Neotropical otter (*Lontra longicaudis*) and giant otter (*Pteronura brasiliensis*) are often reported as a reason for this problem because they invade fish farming tanks, destroy fishing artifacts, and predate the fish (Abade et al. 2007; Marchini et al. 2011; Pinheiro 2016).

In our study area, the otter was mentioned as the main species causing this damage. However, as presented in our results, this type of conflict was not widely reported for the region, which may be related to the low number of participants who captive breed fish and crustaceans since the target public of this work was not fishermen, but farmers.

Animal-Human safety interaction

Direct conflict between humans and wild animals is a major concern worldwide and results in many human victims and retaliations to fauna. Tigers, lions, elephants, hippocampuses, bears, crocodiles, and serpents are among the vertebrates commonly involved in terrestrial attacks (Babai et al. 2017; Dunham et al. 2010; Goodrich 2010; Liu et al. 2011).

Serpents are associated with risks to human health, whether poisonous or not, due to a negative image attributed to this group (Babai et al. 2017). However, a small number of species was attributed to this category in the study area, when compared to other works (Alves et al. 2012; Mendonça et al. 2011). The majority of participants did not report animals, regardless of the group, as a direct threat to people. Even when the interviewees did consider some species as being dangerous, they also accepted these animals were not a potential risk when kept at a safe distance.

Animal-Property interaction

Bats and mice were the only species reported in this type of conflict in the study area. Braga et al. (2016) also registered that mice and elephants damage properties in a study about conflicts in Angola. Furthermore, Arciniegas *et al.* (2015) reinforced problems with bats in Armenia, Quindío-Colombia.

Bats can use human structures as perches and they are known to adapt to urban landscapes with different constructions and survive in areas occupied by people when they lose their habitat (Rego et al. 2015). Despite this characteristic and bad reputation, conflicts with bats were reported by only one participant.

In general, invasion of properties by wild animals was rarely reported in this region, probably because bats, mice, and other wild animals do not frequently cause damage in the study area or are not considered a source of conflicts.

Control measures

Regarding offensive methods, slaughtering is the most common measure directed to species that cause damage in several regions of Brazil (Barbosa and Aguiar 2012; Lobão and Nogueira-Filho 2011; Mendonça et al. 2012; Palmeira and Barrelas 2007; Rocha-Mendes et al. 2005; Trinca and Ferrari 2006). The use of domestic dogs to scare wild animals away, classified in this study as offensive because it poses a risk of injury or death, is also widely registered in other studies. Moreover, dogs are normally used to alert the presence of wild animals or even kill animals near residences (Rocha-Mendes 2005; Palmeiras and Barrella 2007).

Lower tolerance associated with the negative reaction of humans regarding some species is probably linked to frequent and

intense effects on products of economic value or products considered fundamental for the subsistence of farmers (Hill 2004; Naughton-Treves 2001). As Dickman (2010) affirms, for people who depend on only one type of subsistence, the strategy of control tends to be antagonistic to dangerous species. In this case, the destruction is intensified by the lack of alternative assets or alternative income.

Additionally, some species can be used for feeding after they are slaughtered. The collared peccary, for example, has been widely hunted for food and other uses, which has contributed to the reduction and even extinction of this population in several areas where it is originally distributed (Alves et al. 2016).

The animal species harmed by offensive measures in the present study are not classified as threatened species. However, this damage, together with the hunting, still occurring in the study area (Ribeiro and Schiavetti 2009; Teixeira 2018), may affect the permanence of these species in the region.

In the studied communities, defensive methods are the most commonly used. According to interviewees, scare-away strategies for parakeets and chopi black-birds are not considered very efficient, since birds quickly get used to them and strategies must be combined to avoid losing all production. Santos-Neto and Gomes (2007) observed the same behavior in their work about corn predation by the Lear's macaw (*Anodorhynchus leari*) in the Bahia wilderness.

As observed in the study area, the use of aromatic plants to scare away bats was also registered by Arciniegas *et al.* (2015).

The total or partial confinement of domesticated animals as a measure to avoid predation by carnivores seems to work, according to the informants, although some species are still able to attacks the chickens depending on the physical structure of the facilities. Confinement and use of fences are also widely used, mainly in the rearing of cattle, goats, and sheep (Borges et al. 2017; Palmeira and Barrelas 2007; Rocha-Mendes 2005).

For the collared peccary, some of the scare-away methods proved to be effective. According to the interviewees, removing the weeds from inside and around the crops and attending to the fields regularly to leave traces of human scent, associated with the use of scarecrows, seems to reduce the appearance of the collared peccary in the plantations.

Management strategies and preventive measures have been pointed out in researches and specific works on the subject, especially changing the time of planting, anticipating harvest, diversifying agriculture, confining domesticated animals at night, the use of electric fences and screens, scarecrows and trained dogs as a form of alarm, monitoring fauna based on participatory planning and environmental education work (Jacinto et al. 2007; Marchini et al. 2011; Palmeira and Barrelas 2007; Pitiman 2002; Trinca and Ferrari 2006). However, it should be emphasized that the success of control measures depends heavily on the local context, thus, understanding people's expectations before any intervention can enable the development of mitigation strategies that satisfy all stakeholders (Hill, 2004).

Perceptions and attitudes towards fauna are constituted beyond personal facts, experiences, and perceptions, and they are based on factors such as values, knowledge, norms, expectations, beliefs, and broader social experiences (Dickman 2010; Drews 2002). For this reason, cultural aspects that

involve traditions, myths and superstitions of a society also influence the way people relate to animals. In the studied communities and according to the interviewees, the use of control methods based on rituals and superstitions effectively minimizes or prevents damage caused by wildlife.

When the participants were asked who had taught them to use these strategies and defensive methods, they reported that the knowledge was acquired from family members or older people through generations, from close friends and from the experiences of neighbors. Similarly, Toledo and Barrera-Bassols (2009) found that traditional or local knowledge is the result of at least three strands: historically accumulated experience transmitted through generations, experience that is socially shared by the members of the same generation and personal experience of the producer and his or her family.

As shown in our results, a species influences the attitudes and behavior of people in conflicts. Many informants interact positively with animals they consider charismatic, especially bird species. These species are admired for their colors and song and they are among the most widely smuggled animals in the wild (Alves 2012).

According to Torres *et al.* (2018), many species involved in conflicts are charismatic and attract the attention and admiration of people, which is a factor that must be explored in the conservation of these animals. In addition, many participants recognize and emphasize the need for and importance of protecting and conserving their environment and fauna, regardless of the group.

The ecological role of some species was also recognized, as in the case of the indigo snake (*Drymarchon corais*). According to the specialized literature, serpents are part of the diet of *Drymarchon corais* (Argôlo 2004) and the same justification was described by Mendonça *et al.* (2011) for the *cobra-preta* (*Boiruna sertaneja* Zaher, 1996).

Greater tolerance for conflict was also identified, especially when the damage caused by the wild animal is not considered financially harmful, either because the damage is very small or infrequent or when the affected crop is only used for consumption. In addition, factors such as species type and size, visibility, rarity and devastating events, danger level and self-control in the situation influence the degree of risk perception in relation to animals that may cause damage (Dickman 2010; Hill 2004; Naughton-Treves 2001).

CONCLUSIONS

The ethnozoological approach adopted in this work allowed the diagnosis of conflicts from the perspective of farmers, which are directly affected by this problem. As a result, 45 species of mammals, birds, and reptiles involved in five categories of conflict interactions were identified.

Negative impacts caused by wild fauna affect crops and animals that are essential to the subsistence of the interviewees and their families. For example, damage to cassava, cocoa, corn, and banana crops, as well as the effect on chicken rearing increase the damage and can influence the tolerance of the studied communities to the presence of some species in the region.

The recognition of defensive measures of prevention and positive interaction between the participants and local fauna is an important factor for mediating conflicts and should be reinforced and encouraged in the communities. On the other hand, offensive strategies were also reported, leading to the harming or killing of animals, which may

reduce the species in the region and directly affect conservation efforts.

The priority for biodiversity conservation in an area with two important Conservation Units - APA Costa de Itacaré-Serra Grande and Serra do Conduru State Park - should be the creation and implementation of new strategies to solve or reduce conflict. These strategies are also important for social and economic reasons and to guarantee the efficient management and conservation of local fauna, mainly for the species with the highest number of reports. Moreover, they must be created together with the local population and environmental managers based on all the environmental, socioeconomic and cultural dimensions involved in conflicts between humans and wild animals.

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